Model Remote Control

using an IR remote controller

If you thought that an infra-red (IR) controller was only good for zapping TV channels then read on. This novel circuit uses a micro controller to decode RC5 format IR signals and put them to a better use...

This compact circuit is designed to allow a model car, boat or robot etc. to be controlled from a handheld remote controller that would normally be used to control a TV, audio amplifier or satellite receiver. The only requirement is that the IR remote controller must send control messages using the RC5 format.

At the heart of the circuit is a COP8782 micro controller from National Semiconductor, this interprets the infra-red signals and sends out proportional signals to control a model servo for steering. It also has a MOSFET bridge circuit to drive a motor for forward, stop and reverse functions.

Infra-red receiver with µC support

The infra-red control signal is received by IC3. This device includes a high sensitivity photo diode, amplifier, filter and demodulator for picking up the 36 kHz modulated signals. The device specified can be either a SFH5110-36 from Siemens or a TSOP1736 from Temic. **Figure 1** shows the internal block diagram of this three pin device.

The complete receiver circuit diagram is shown in **Figure 2.** The demodulated signal from IC3 is connected to the G0 input of the micro controller IC1. The micro controller performs error detection and interprets the received RC5 format message. R8 and C4 form a low pass filter to de-couple any interference on the supply to IC3. IC2 produces The 5 V supply to the circuit and requires an input voltage of 9.6 V (equivalent to 8 nicads). IC2 can be replaced by a low-drop regulator equivalent and this would allow operation from a 7-cell nicad pack.

The microcontroller used here should be no stranger to regular readers of Elektor Electronics, it has been used many times in the past, just to re-cap its main features:

- 4096 x 8 OTP EPROM
- 128 Bytes RAM
- 1 µs cycle time at 10 MHz
- 16-bit-Timer with the operational modes:
  - Timer with auto-reload
  - Timer as External Event Counter
  - Timer with Capture function
- 16 I/O connections, 14 of these can be configured as outputs or inputs.
- Selectable output pin configuration: Tri-State, push-pull or pull-up
- Microwire interface
- Interrupt sources:
  - External Interrupt, selectable on rising or falling edge
  - Timer Interrupt
  - Software Interrupt

For the (steering) output signal to the servo the internal timer is used in its Timer with Auto-Reload mode. Once this mode has been programmed during reset initialisation of the chip, the timer will output a defined pulse repetition on pin G3 without any further software intervention. The output signal required to control the majority of servo types should be a pulse of between 0.9 and 2.1 ms with a repetition rate of around 20 ms. To position the servo mid way in its travel a pulse width of 1.5 ms is necessary whereas 1.00 ms will move it to its minimum position and 2.0 ms to its maximum position. This is the so called **pulse**

Features

Controlled by an RC5 infra-red signal

Connections:	Model servo Model drive motor
Motor control:	Forward/Stop/Reverse
Operating range:	approx. 10 m

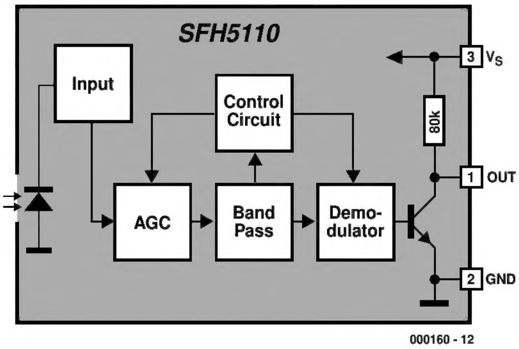

Figure 1. Block diagram of the IR receiver chip.

width modulation (PWM) method of proportional control.

In the last few years all servos sold in the U.K. irrespective of manufacturer have identical pin configurations so there should only be a problem with the servo connector if you are using older servos. The signal names of the servo output pins are printed on the PCB so it is possible to work out the correct connection if you are using these older type servos (refer to the pin layouts used by the servo manufacturers in **Figure 3**). It is important to wire the servo correctly, you risk damaging the servo and this circuit if you mix up the wires. The layout of the servo connector on the PCB will allow a 1-to-1 connection to all modern servos.

Output pins L6 and L7 are used to control the models drive motor. These are used to switch Logic-Level Power MOSFETs connected in a bridge configuration. This type of MOSFET can be driven directly from a 5 V logic signal. The types used here have an $R_{ds(on)}$ of about 0.1 Ω and can easily handle a motor current of 4 A. If you intend switching higher currents then it will be necessary to fit a heat sink or replace the MOSFETs with types having a lower $R_{ds(on)}$. The gates of these devices are connected to ground via 100 kΩ resistors R3 and R4, these ensure that the MOSFETs remain switched off when the micro controllers output pins are briefly tri-stated during initialisation of the micro controller. Diodes D3 to D6 are used to protect the MOSFETs from reverse voltage spikes generated by the motor.

A reset signal is produced by the network formed by R1, C1 and D1. LED D2 flashes each time a RC5 coded message is successfully received. This gives a good indication that the remote control link is working correctly.

IR signals in RC5 format

The RC5 code was developed by Philips and is currently the most widely used standard for European entertainment equipment. All RC5 compatible remote controllers must conform to the RC5 message protocol standard. Each message is composed of 14 bits and is made up of the following fields:

- 2 Start bits to allow the AGC in the receiver to adjust its level.
- 1 control bit indicating the start of a new message.
- 5 bits indicating the system address. (MSB - LSB).
- 6 bits containing the message command. (MSB - LSB).

To reduce the intermodulation effects produced when the IR signal is mixed with other sources of IR interference (e.g. incandescent lamps) the message is sent using biphase encoding. With this method the data signal changes state mid-bit, a falling edge indicates that the data bit is a zero, a rising edge indicates a logical one. The data signal will also change state at the end of a data bit if the next bit has the same value as the present bit (see **Figure 4**).

The time taken to send one complete message is 113.778 ms which is made up of 24.889 ms for the message information followed by a gap of 88.889 ms. The carrier frequency is 36 kHz. A single control bit (toggle bit) in the message is used to tell the difference between pressing a key again and holding a key down, it changes its value (or toggles) only when a key is first pressed. This feature often creates problems for the re-programmable type of remote controller that 'learns' the control sequences from an existing controller.

Five bits following the toggle bit form the address field and are used to identify the type of equipment. This ensures that the remote controller for the stereo does not control the TV. The TV simply ignores messages that are

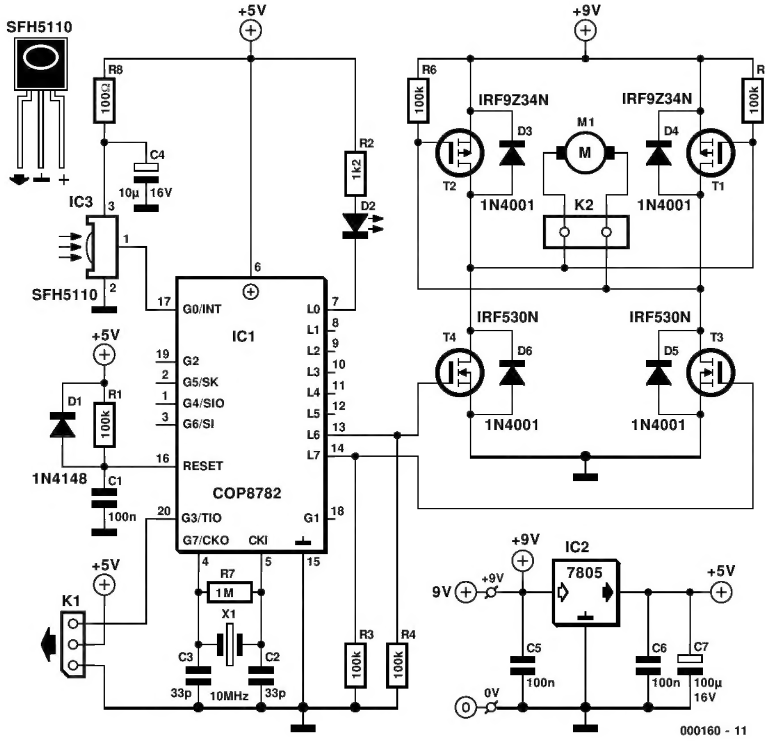

Figure 2. The complete circuit with IR receiver, Microcontroller and motor driving bridge.

addressed to the stereo and vice versa. This is similar to the operation of the address bus of a processor.

The next six bits are used for sending commands to the equipment. For example to increase sound volume of the equipment (Master Volume+) command 16 would be sent. This command field would be the same irrespective of the type of equipment being controlled. This allows equipment to be controlled by a remote controller device from a different manufacturer. An article in the March and April 2001 editions of Elektor Electronics provides detailed information of the codes used for this and other IR communication standards.

Input G4 (pin 1) of the controller chip is used to alter the way in which the controller handles the RC5 messages. If the G4 input is hard-wired to ground this controller circuit will only respond to commands sent out by a remote controller for a stereo amplifier (address 17). Leaving G4 open–circuited (it has an internal pull-up resistor) ensures that the controller responds to any RC5 compatible remote controller, it simply ignores the address field in the message.

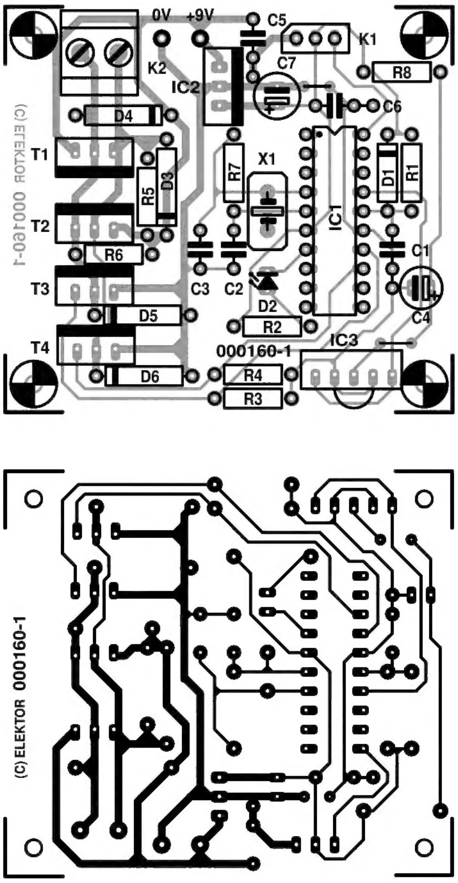

Figure 5. Layout and component placement of the double-sided PCB.

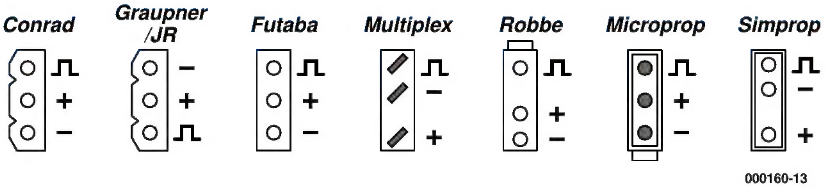

Figure 3. Pin assignments for different makes of servo. (view from underside)

Construction and use

The double-sided PCB is shown in **Figure 5**. It is small enough to fit easily inside a model car or robot. Fitting the components should not pose too much of a problem providing that you are careful and observe the correct polarity of the important devices. After a careful visual check of your soldering handiwork you can apply power to the circuit (initially with no output load connected to the circuit) and then fit the board into the model.

When mounting the infra-red receiver in the model make sure that you position it so that it can pick-up the transmitted IR signals from any direction, mounting it on the top of the model will probably be best, preferably on a reflective surface to optimise the received IR signal.

Unlike conventional radio model remote control equipment it is only possible to issue one command at a time, pressing two keys at once will have no effect. This control method is a little awkward at first and takes some getting used to but after a little practice it should be possible to gain smooth control.

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Model control functions with the IR remote controller.

VOL- key	Servo left
VOL+ key	Servo right
key 3	Motor reverse
key 2	Motor forward
key 1	Motor stop

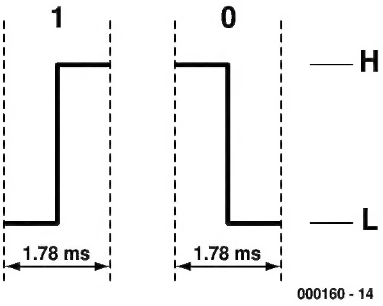

Figure 4.biphase encoding.

COMPONENTS LIST

Resistors:
R1,R3-R6 = 100kΩ
R2 = 1kΩ2
R7 = 1MΩ
R8 = 100Ω

Capacitors:
C1,C5,C6 = 100nF
C2,C3 = 33pF
C4 = 10µF 16V radial
C7 = 100µF 16V radial

Semiconductors:
D1 = 1N4148
D2 = LED, red, high efficiency
D3-D6 = 1N4001
T3,T4 = IRF530N (Conrad Electronics # 158747,Farnell #637-439)
T1,T2 = IRF9Z34N (Conrad Electronics # 159166, Farnell # 934-677)
IC1 = COP8782, programmed, order code **000160-41**
IC2 = 7805
IC3 = TSOP1736 (Conrad Electronics # 171069), SFH5110-36 (Siemens), PIC26043SM (Farnell # 139-877), IS1U60 (Sharp) or TFMS5360, see text

Miscellaneous:
X1 = 10MHz quartz crystal
K1 = 3-way pinheader
PC1,PC2 = solder pins
K2 = 2-way PCB terminal block, lead pitch 5mm
PCB, order code **000160-1**
Disk, contains source and hex files, order code **000160-11**